Leibniz Centre for
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Simulation of Dynamic Adaptation of Social-Ecological-System in Agricultural Landscapes

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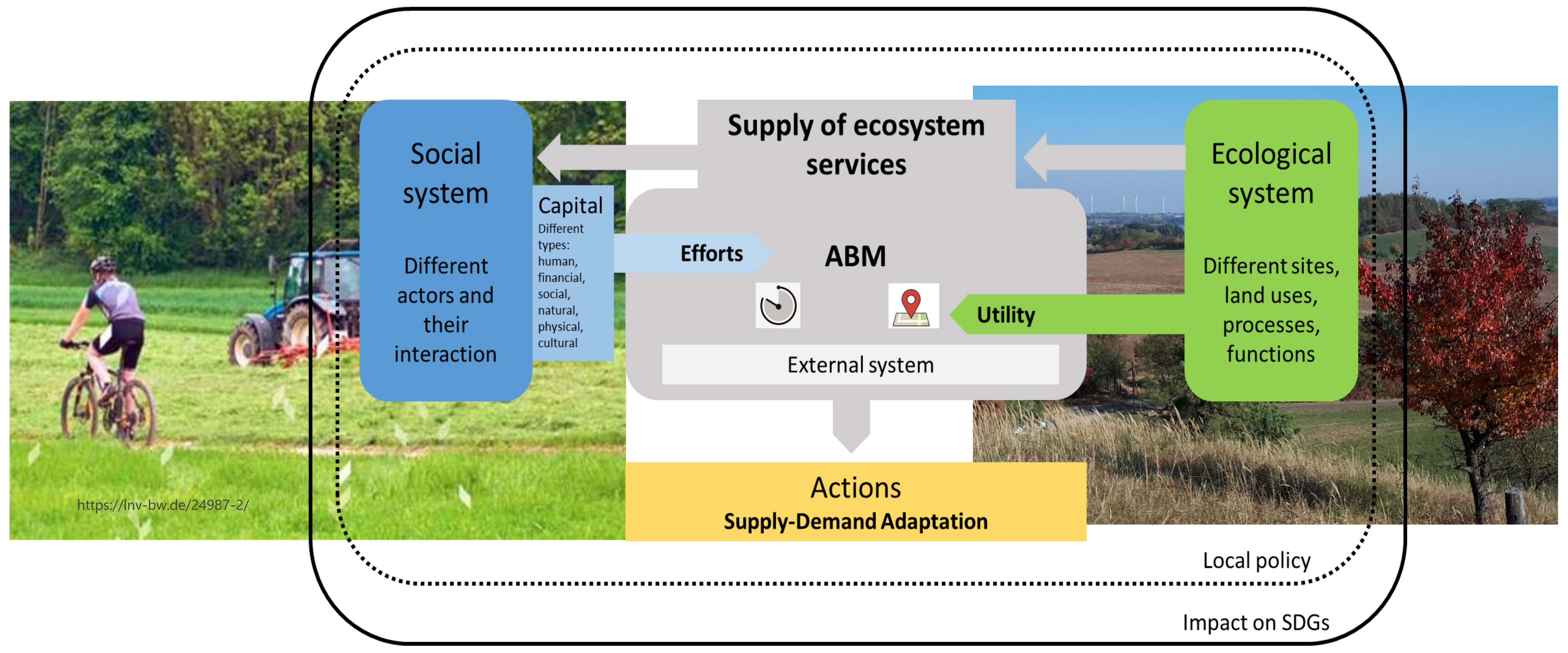
Challenges

- Tradeoffs between social benefits, demands and ecological conservation evoke debates and conflicts amongst multiple stakeholders.
- Complexity of some systems, e.g. social-ecological agroecosystem, poses a lot of challenges with classical modelling tools.

Research objectives

- Mitigating risks of conflicts between actors.
- Reducing the gap between the supply of and the demand for ecosystem services.

Conceptual framework on social-ecological system



Approach: Spatial ABM

We develop the "**Viability of the Social-Ecological Agroecosystem**" **(ViSA) spatial agent-based model** which

- simulates the interactions between the demands of different actors for ecosystem services in agricultural landscape and
- depicts the evolution of their capitals in response to their adaptive decision behavior to the change in the system.

We examine a hypothetical example of three dummy actors showing demands for ecosystem services in Märkisch-Oderland, Brandenburg, Germany and apply different management options and decision rules. The model has been programmed in Netlogo 6.1.1 software.

Competitive-gradient

$$\Delta E_a = \beta E_a (E^+ - E_a)\left(\sigma_a - \sum_b \omega_{ab} E_b - \omega_{aa} E_a\right)$$

$$\Delta p_a^k = \alpha p_a^k \left(v_a^k - \sum_l p_a^l v_a^l\right)$$

$$v_a^k = E_a\left(\frac{u_0^k}{e_a^k} - \left(\sum_b E_b z^k \frac{p_b^k}{e_b^k e_a^k}\right) - \left(E_a z^k \frac{p_a^k}{{e_a^k}^2}\right)\right)$$

ΔE_a: rate of change in effort
β: adaptation rate of effort change
E_a: the total applied effort by actor (a)
E^+: max effort
σ_a: benefits from self efforts
ω_{ab}: the mutual coupling with other actors (b)
Δp_a^k: rate of change in priority for ESS k
α: adaptation rate of priority change
p_a^k: the priority for ESS k
v_a^k: partial change in utility with partial change of priority (marginal value)
u_0: the initial unit utility
e_a^k: efforts applied to make a unit change of ESS k
z: the rate of change of the unit utility

Cooperative-optimizing

$$F_a^k = q_a^k p_a^k E_a \left(1 - \frac{s^k}{d_a^k}\right)\frac{s_{act}}{s_{per}}$$

$$F^{k^*} = \left(\frac{N_x^k + (H_x^k)_{damage}}{s_x^k}\right) - r^k\left(1 - \frac{s_x^k}{P_x^k}\right)$$

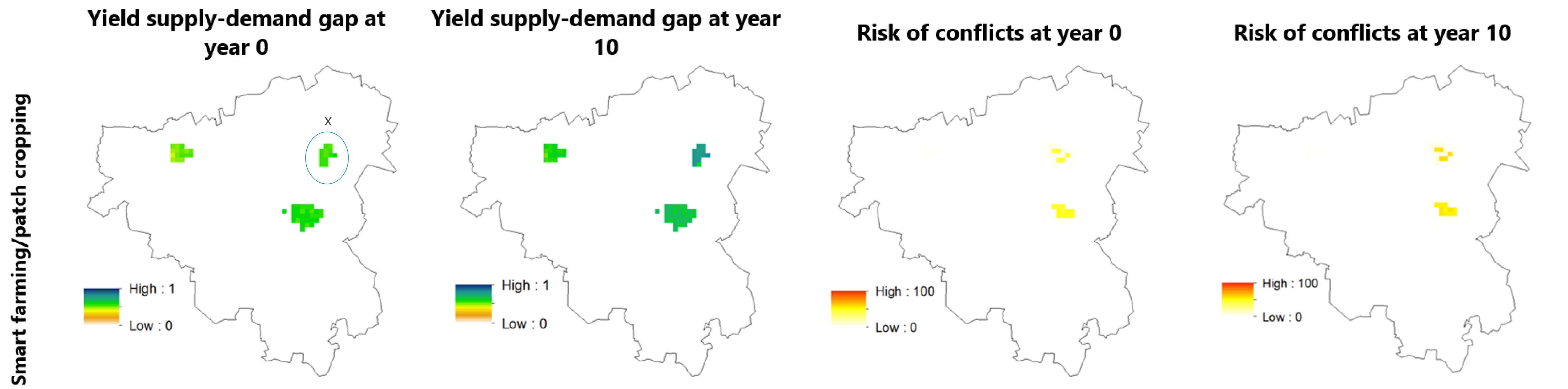
$$\Delta F^k = \gamma^k (F^{k^*} - F^k)$$

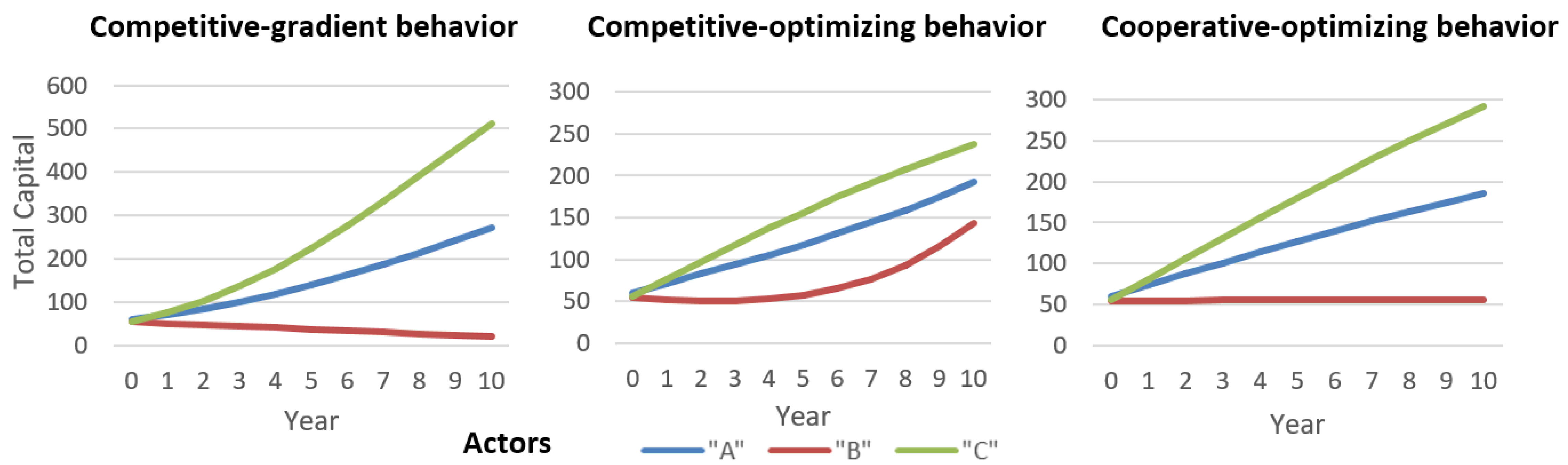
$$\Delta E_a^k = \frac{\Delta F^k \varphi_a^k}{q_a^k}$$

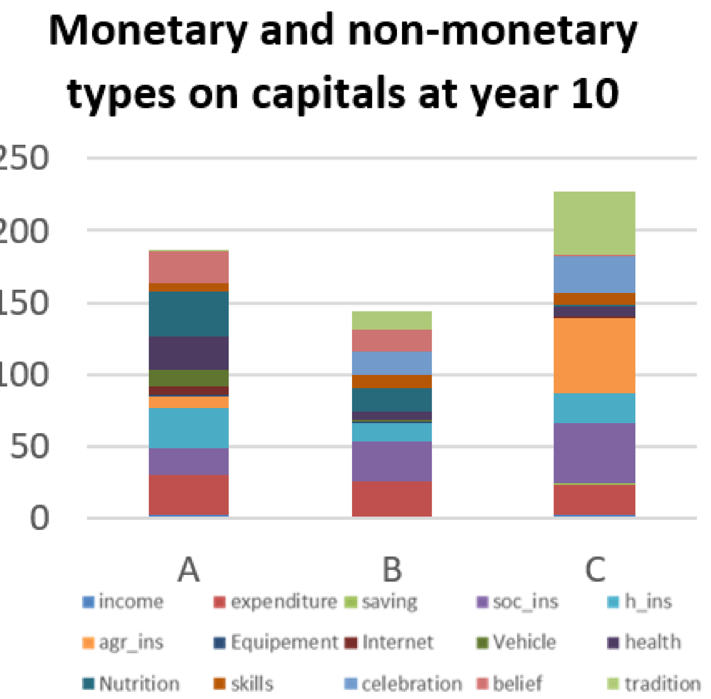
F_a^k: contributed effort by actor a in the total effective effort
q^k: efficiency of the applied management option
s_x^k: current supply at location x
d_a^k: demand for ESS k
s_{per}: perceived supply of ESS k
N_x^k: amount depleted due to external factors (e.g. climate change, pandemics, wars)
H_x^k: amount depleted due to human intervention
r_x^k: natural restoration rate
P_x^k: max potential of ESS k
F^k: total effective effort for ESS k
γ^k: adaptation rate of total effective effort change
F^{k^*}: target total effective effort for ESS k
φ_a^k: the share of actor a in the total effective effort

Results: Example smart farming / patch cropping

In demand area x, smart-farming/patch cropping under cooperative-optimizing scenario has been recommended.







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